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Education for Sustainable Development in Higher Education: State-of-the-Art, Barriers and Challenges

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Abstract: Education for Sustainable Development (ESD) is a new educational paradigm that allows Universities to lead and respond to social needs towards a more sustainable life. The ESD is a global preparedness and complex phenomena in relation to the effects of human activity on the environment, society and economy in spatial (global, regional and local) and temporal dimensions (learn from the past, act in the present and anticipate the future). This essay provides an important synthesis of the vast literature in recent years in relation to ESD. It analyzes the areas and elements to be integrated into the application and integration of Sustainability in Higher Education (SHE), the importance of sustainability curricula and changing the teaching and learning methods into more participative and active techniques. The essay ends with a proposal of steps to follow to implement a sustainability plan, the various existing integration strategies, and the identification of barriers and remaining challenges into ESD.

Keywords: Education for sustainable development (ESD), sustainability in higher education (SHE), sustainable development (SD)

Introduction

The need for a Sustainable Development (SD) in all human activity has been established as a fact. Thus, sustainability integrates the complexity of social, economic, and ecological, so that people could live with equal rights and duties and the economy could allow a fair distribution of wealth to cover basic needs and optimizing the use of resources, respecting all forms of life and preserving biodiversity. SD consists in finding the balance between the development of human societies and the natural cycle dynamics.

Currently, it is accepted that these three dimensions should have the same relevance, order, and importance. Sustainability is therefore a balanced interaction of these three concepts (triple bottom line). This concept was first described in the business world in order to implement the concept of sustainability (Elkington, 1994). The current concept of sustainability is tending to

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differentiate these three dimensions, but the continuous economic variable currently has a greater importance on the rest (Ségalas, 2009). The other approach established the environment as the context and the limiting factor in all decisions. Subsequently, society and culture are actors on the environment and decisions must be prioritized to meet the needs of the population. Finally, it would be the economic dimension as a medium of exchange to support social and environmental relations and not vice versa.

Education for Sustainable Development (ESD)

Sustainability has reached the field of education, especially in universities which have been linked to sustainable development since its inception. Even though the concept was not fully defined in the Stockholm Declaration of the United Nations Conference on the Human Environment in 1972, it proposed the necessary interconnection between education and sustainable development.

There is a consensus in the literature that higher education institutions are crucial in the global efforts for reaching a sustainable development (Calder & Clugston, 2003; Mochizuki & Fadeeva, 2008; UNESCO, 2009). The literature has proposed to promote a solidarity education, overcoming the tendency to guide behavior based on short-term interests, or simple habit that contributes to a correct perception of the state of the world, building responsible behavior in students and preparing them to make decisions aimed at achieving a culturally pluralistic development and sustainable physically (Delors, 1996).

At the World Summit on Sustainable Development held in Johannesburg, in 2002, in the Ubuntu Declaration on Education and Science and Technology for Sustainable Development, education was also recognized as a fundamental pillar for the implementation of sustainable development (UNESCO et al., 2002). Also, in December 2002, the General Assembly of the United Nations declared the decade of Education for Sustainable Development 2005-2014. It was stressed that education must play a key role in order to ensure sustainable livelihoods opportunities and future for young people (UNESCO, 2009). There are many statements relating to sustainability in higher education such as the Talloires Declaration of 1990, the Halifax Declaration of 1991, and the COPERNICUS University Charter for Sustainable Development established in 1993. A review of all declarations, charters, and partnerships related with ESD from 1972 has been developed by Lozano, Lozano, Mulder, Huisinigh, and Waas (2013).

For some authors, ESD is a complete change in the global paradigm of education and involvement of society as they feel that education is often part of the problem as it encourages individualism, the unsustainable lifestyles, and consumption patterns, directly or by default (Wade, 2008). ESD would be a paradigm shift in curricula development to meet future social needs (Pavlova, 2009). The Sustainable Development Education Network defines ESD as “the process of acquiring the knowledge, skills and attitudes needed to build local and global societies that are just, equitable, and living within environmental limits of our planet, both now and in the future” (Environmental Association for Universities and Colleges, 2013).

Universities have begun the way to ESD, but are still relatively new concepts in most universities (Ferrer-Balas et al., 2010; Jones, Selby, & Sterling, 2010; Lozano, 2012) or stayed still far from a complete integration into university operations and curricula (Hanover Research, 2011; Waas, Verbruggen, & Wright, 2010; Wright & Wilton, 2012). In fact, only 15 of more than 14,000 universities worldwide have published their sustainability reports (Lozano, 2011). However, it is commonly accepted that education is a key element in the change and transformation of behavior and practices towards sustainable living (Yasin & Rahman, 2011).

University as a Complex System

The university as a whole is a complex system that interacts with multiple stakeholders and in different areas where the ESD does not apply only to the curricula. It is essential to focus on the integration of sustainability across all of its activities, responsibilities, and mission (Lee, Barker, & Mouasher, 2013). According to Lidgren, Rodhe, and Huisinigh (2006) and Lozano (2010), sustainability must be integrated in the areas of Education, Research, Campus Operations, Community Outreach, and Assessment and Reporting (see Figure 1). Logically, it has been given special importance to the development of programs that integrate knowledge, skills and values related to sustainability in university programs (Ségalas, Ferrer-Balas, Svanström, Lundqvist, & Mulder, 2009). In addition, institutional support must reflect its interests in the mission and vision of the University (generic definition of ESD) and in each school and faculty (specific definition of ESD), as well as in the graduate attribute statements (Lee et al., 2013).

According to the various initiatives and declarations to the ESD (Lozano et al., 2013), there is a consensus on the importance of the curricula, research, outreach, transdisciplinarity, operations, and collaboration between universities that are established as key areas.

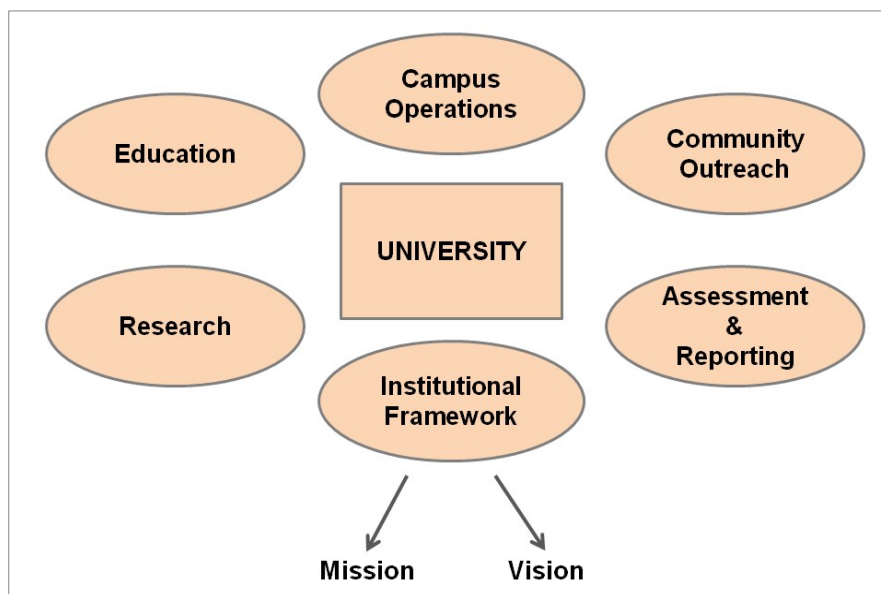


Figure 1. University areas where ESD has to be integrated.

There are approaches that begin to assess the sustainability of some of the areas mentioned in relation to certain social, economic, and mainly environmental. Thus, there are some approaches to analyze the energy consumption and carbon footprints of universities (Klein-Banai & Theis, 2013; Larsen, Pettersen, Solli, & Hertwich, 2013), the ecological footprint, and campus sustainability (Beringer, 2006), trying to study the impacts but also the improvement capacity in academic endeavor. In addition, there are numerous tools of sustainability assessment at various aspects of Higher Education (HE), such as the Shriberg (2002) review; although, there are some recent approaches: AISHE, Auditing Instrument for Sustainable Higher Education (Roorda, 2001); GASU, Graphical Assessment of Sustainability in Universities (Lozano, 2006); and STAUNCH, Sustainability Tool for Assessing Universities' Curricula Holistically (Lozano, 2010). However, they are still indicator based guidelines to serve as an improvement and support in the implementation of sustainability in HE. In addition, there are universities that certify sustainability of courses using an eco-labelling based on related content of SD (e.g., Boman & Andersson, 2013).

Within the ESD, it is essential to take into account all stakeholders: employers, community, research centers and universities, students, faculty, staff, and funding bodies, as well as local and regional administrations (Quist & Tukker, 2013; Van Weenen, 2000). The ESD has hardly been analyzed from the points of view of various stakeholders; although, some studies have made an attempt. From the point of view of students, Lagrell (2009) has identified that students are mostly quite familiar with the concepts of SD, much more than teachers. Authors such as Elshof (2005) and Pavlova (2012) highlight need for training and sensitization of teachers. On the other hand, Kagawa (2007) concluded that students continue to link sustainability with environment, and not that much with both social and economic aspects. From the perspective of students, a university is seen as sustainable when they have a minimal environmental impact, the highest level of social responsibility, and an important economic and social contribution (Nejati & Nejati, 2013).

According to Emanuel and Adams (2011), students are proactive in participating in sustainable initiatives linked in campus activities. Students also cited the need for guidance on integrating sustainability into design process of their projects or works (Watson, Noyes, & Rodgers, 2013). The awareness of students is a fundamental element (Beringer, 2006), but it is also important to take care of all actors. The integration of different stakeholders in the implementation of a university sustainability plan is strongly recommended. In fact, according to recent research (Hanover Research, 2011), companies attach great importance to education in sustainability when considering that jobs related to these topics in the UK will increase by 20% between 2008 and 2018, and 52% in U.S. between 2000 and 2016 (Schmidt, 2009); the sustainability-related skills are also important in developing the work in a company; and, finally, the continuing importance of specific skills and technique knowledge that are still the most valued is emphasized.

Sustainability at the University can be broken down into internal (related to the areas of campus operations, research, and institution framework) and external sustainability (community outreach and assessment and reporting). Some authors (e.g., Lozano et al., 2013) noted that these areas can be managed and assessed as other corporations do by developing sustainability reports, as the already known Global Reporting Initiative (GRI) with minor

modifications for the HE sector.

The integration of knowledge, skills, and values in the plans and programs of each academic degree is also a basic feature (within the education area). Wiek, Withycombe, and Redman, (2011) conducted a thorough review of the competences used in ESD and methods for their development. The five key competencies proposed were: systems-thinking, anticipatory, normative, strategic, and interpersonal competences. Nonetheless, other authors, such as Roorda (2010), proposed six areas of competence: responsibility, emotional intelligence, system orientation, future orientation, personal involvement, and action skills, highly valued and used (Lambrechts, Mulà Pons de Vall, & Van den Haute, 2013). According to Ségalas et al. (2009), there is some consensus on the primary meaning of the competencies to be developed but not in the description, level of acquisition, teaching, and learning processes. It is, therefore, necessary to a certain homogeneity criteria permitting greater harmoniousness, comparison and transferability.

Strategies for Integrating Sustainability in Higher Education

There are several approaches for the integration of sustainability at the university level. Rusinko (2010) proposed four forms of integration that vary, depending on the combination of two variables: the maintenance of the general structures of the degree (or creating a new structure) for the implementation of sustainable aspects and the focus given to sustainability (specific of each discipline or more cross-cutting and interdisciplinary). In addition, there are several ways to start the implementation: the top-down process, posing it at the institutional level and transmitting it to schools, departments, degrees, and faculty; and bottom-up, from active faculty but with definitive need of institutional support (Hanover Research, 2011).

The integration of competences for SD according to Lambrechts et al. (2010) can follow the vertical strategy, integrating elements of SD as the only key skill or course; horizontal strategy, with integrated SD elements implicitly in all competences; or through a combined integration, which integrates the elements of both transversely and specifically SD competences. Each strategy will depend on the context of each university, resources, institutional support, and the goals sought, since there is no optimal strategy in respect to the others. Nonetheless, in any process of integration of ESD, the following steps should be taken:

- Mission and vision: establish a definition of SD at the institutional level (general), and at school and faculty level (specific definition).
- Apply sustainable criteria in the activities of all areas identified in the university, in accordance with the mission and vision statement.
- Definition of knowledge, skills, and values (both generals and specific) linked to the previous operational definition of SD.
- Establish new teaching processes for new educational objectives (e.g., Moreira, 2012) in order to refocus teaching and learning processes based on transdisciplinary, problem-based education and project based learning, self-regulated learning, interactive and participative techniques, and action oriented and research-based methods.
- Determine skill acquisition levels and coordinate the progress within these skills.

Graduates must satisfy the knowledge requirements related to sustainability.

- Acknowledge the importance of informing and guiding students: feed-up, feed-back, and feed-forward.
- Seek a continuous improvement process in all areas of the university (education as central area but not the only one: the importance of the example). For instance, evaluations, reporting, and certifications and accreditations (if any).

Barriers, Problems and Future Challenges

The main problems identified are related to the need for leadership, incentives, knowledge, and resources for the successful implementation of sustainability in HE. In addition, regardless of whether the integration process is top-down or bottom-up, significant support from the top management is needed. For Velázquez, Munguia, and Sánchez (2005), the main problems come from the lack of funds, interest, and support of university administrations. This in turn affects the communication, information, training of faculty, lack of time, and centralization of ESD-related activities in a university environment. Ultimately, the ESD is a strong commitment at the institutional level.

Teacher training and the need to make the ESD more explicit within degrees and areas of the university are key elements for the success of a sustainability plan. A framework with maximum consensus of faculty is needed; hence, the importance of bottom-up strategies, but with a significant institutional support. The changes to the ESD involve changes in how to perform all activities and, therefore, should permeate all areas and departments. Thus, all activities within the university should be involved and have a voice in the coordination and implementation of sustainability. The most profound change is at the educational level, which not only modifies or extends the knowledge, skills, and values of the students towards sustainability, but also evolves teaching strategies such as the creation of role-plays, simulations, discussion groups, debates, case studies, critical reading, problem/project based learning, and modeling good practice (UNESCO, 2011).

A critical problem is that existing and proposed methodological statements do not give concrete operational level requirements of what universities should do exactly to contribute to SD (Lee et al., 2013). Therefore, a comprehensive plan is necessary for the implementation of ESD at the university level that includes not only the knowledge, skills, and values based on SD, but also an integration of the principles from the upper echelons (mission and vision), an important institutional support to the teams responsible for the coordination of sustainability at the university and at each school and faculty, to look for and keep sustainability goals in all areas of the university: education, research, campus activities, outreach, and assessment and reporting.

References

- Beringer, A. (2006). Campus sustainability audit research in Atlantic Canada: Pioneering the campus sustainability assessment framework. *International Journal of Sustainability in Higher Education*, 7(4), 437-455. <http://dx.doi.org/10.1108/14676370610702235>
- Boman, J., & Andersson, U. P. (2013, June). Eco-labelling of courses and programs at University of Gothenburg. *Journal of Cleaner Production* 48, 48-53. <http://dx.doi.org/10.1016/j.jclepro.2011.10.024>

- Calder, W., & Clugston, R. M. (2003). International efforts to promote higher education for sustainable development. *Planning for Higher Education*, 31(3), 30-44.
- Delors, J. (1996). Learning: the treasure within. Report to UNESCO of the international commission on education for the twenty-first century. Paris, France: UNESCO Publishing Press.
- Environmental Association for Universities and Colleges. (2013). *Embedding sustainable development in the curriculum*. Retrieved from <http://www.eauc.org.uk>
- Elkington, J. (1994). Towards the sustainable corporation: Win-win-win business strategies for sustainable development. *California Management Review*, 36(2), 90-100. <http://dx.doi.org/10.2307/41165746>
- Elshof, L. (2005). Teacher's interpretation of sustainable development. *International Journal of Technology and Design Education*, 15(2), 173-186. <http://dx.doi.org/10.1007/s10798-005-8277-1>
- Emanuel, R., & Adams, J. (2011). College students' perceptions of campus sustainability. *International Journal of Sustainability in Higher Education*, 12(1), 79-92. <http://dx.doi.org/10.1108/14676371111098320>
- Ferrer-Bala, D., Lozano, R., Huisingh, D., Buckland, H., Ysern, P., & Zilahy, G. (2010). Going beyond the rhetoric: system-wide changes in universities for sustainable societies. *Journal of Cleaner Production*, 18(7), 607-610. doi: <http://dx.doi.org/10.1016/j.jclepro.2009.12.009>
- Hanover Research. (2011). *Embedding sustainability into university curricula*. Retrieved from www.hanoverresearch.com
- Jones, P., Selby, D., & Sterling, S. (Eds.). (2010). *Sustainability education: Perspectives and practice across higher education*. London, UK: Earthscan. <http://dx.doi.org/10.3390/su2020684>
- Kagawa, F. (2007). Dissonance in students' perceptions of sustainable development and sustainability: Implications for curriculum change. *International Journal of Sustainability in Higher Education* 8(3), 317-338. <http://dx.doi.org/10.1108/14676370710817174>
- Klein-Banai, C., & Theis, T. L. (2013, June). Quantitative analysis of factors affecting greenhouse gas emissions at institutions of higher education. *Journal of Cleaner Production* 48, 29-32. <http://dx.doi.org/10.1016/j.jclepro.2011.06.004>
- Lagrell, E. (2009). *Att lära för livet, En studie om förståelse, föreställningar och attityder i förhållande till hållbar utveckling bland studenter vid Göteborgs universitet* [Learning for life: A study of students' understanding, expectations and attitudes to sustainable development among students at the University of Gothenburg; Unpublished undergraduate dissertation]. School of Global Studies, University of Gothenburg, Sweden.
- Lambrechts, W., Mulà Pons de Vall, I., & Van den Haute, H. (2010, October). The integration of sustainability in competence based higher education. Using competences as a starting point to achieve sustainable higher education. Paper presented at the *Knowledge Collaboration & Learning for Sustainable Innovation: Proceedings of the 6th Conference Environmental Management for Sustainable Universities (EMSU)*, Delft, Netherlands.
- Larsen, H. N., Pettersen, J., Solli, C., & Hertwich, E.G. (2013, June). Investigating the Carbon Footprint of a University – The case of NTNU. *Journal of Cleaner Production*, 48, 39-47. <http://dx.doi.org/10.1016/j.jclepro.2011.10.007>
- Lee, K., Barker, M., & Mouasher, A. (2013, June). Is it even espoused? An exploratory study of commitment to sustainability as evidenced in vision, mission and graduate attribute statements in Australian universities. *Journal of Cleaner Production*, 48, 20-28. <http://dx.doi.org/10.1016/j.jclepro.2013.01.007>
- Lidgren, A., Rodhe, H., & Huisingh, D., (2006). A systemic approach to incorporate sustainability into university courses and curricula. *Journal of Cleaner Production*, 14(9-11), 797-809. <http://dx.doi.org/10.1016/j.jclepro.2005.12.011>

- Lozano, R. (2006). A tool for a Graphical Assessment of Sustainability in Universities (GASU). *Journal of Cleaner Production* 14(9-11), 963-972. <http://dx.doi.org/10.1016/j.jclepro.2005.11.041>
- Lozano, R. (2010). Diffusion of sustainable development in universities' curricula: An empirical example from Cardiff University. *Journal of Cleaner Production*, 18(7), 637-644. <http://dx.doi.org/10.1016/j.jclepro.2009.07.005>
- Lozano, R. (2011). The state of sustainability reporting in universities. *International Journal of Sustainability in Higher Education*, 12(1), 67-78. <http://dx.doi.org/10.1108/14676371111098311>
- Lozano, R. (2012). Organizational learning and creativity as means to foster sustainability in universities. Higher Education for sustainability: A global overview of commitment and progress. In *Higher Education in the World 4. Higher Education's Commitment to Sustainability: From understanding to action*. Basingstoke, Hampshire: Palgrave Macmillan/Global University Network for Innovation.
- Lozano, R., Lozano, F. J., Mulder, K. F., Huisingh, D., & Waas, T. (2013, June). Advancing higher education for sustainable development: international insights and critical reflections. *Journal of Cleaner Production*, 48, 3-9. <http://dx.doi.org/10.1016/j.jclepro.2013.03.034>
- Mochizuki, Y., & Fadeeva, Z. (2008). Regional centres of expertise on education for sustainable development (RCEs): An overview. *International Journal of Sustainability in Higher Education*, 9(4), 369-381. <http://dx.doi.org/10.1108/14676370810905490>
- Moreira, P. (2012). Economic competition, sustainability and survival endurance: The extinction of the Dodo, the Easter Island case and the tragedy of the commons effect. *Higher Learning Research Communications*, 2(4), 23-36. <http://dx.doi.org/10.18870/hlrc.v2i4.84>
- Nejati, M., & Nejati, M. (2013, June). Assessment of sustainable university factors from the perspective of university students. *Journal of Cleaner Production*, 48, 101-107. <http://dx.doi.org/10.1016/j.jclepro.2012.09.006>
- Pavlova, M. (2009). Conceptualisation of technology education within the paradigm of sustainable development. *International Journal of Technology Design and Education*, 19(2), 109-132. <http://dx.doi.org/10.1007/s10798-008-9073-5>
- Pavlova, M. (2012). Teaching and learning for sustainable development: ESD research in technology education. *International Journal of Technology Design and Education*, 23(3), 733-748. <http://dx.doi.org/10.1007/s10798-012-9213-9>
- Quist, J., & Tukker, A. (2013, June). Knowledge collaboration and learning for sustainable innovation and consumption: Introduction to the ERSCP portion of this special volume. *Journal of Cleaner Production*, 48, 167-175. <http://dx.doi.org/10.1016/j.jclepro.2013.03.051>
- Roorda, N. (2001). *AISHE: Auditing instrument for sustainable higher education*. The Netherlands: Dutch Committee for Sustainable Higher Education.
- Rusinko, C. A. (2010). Integrating sustainability in higher education: A generic matrix. *International Journal of Sustainability in Higher Education*, 11(3), 250-259. <http://dx.doi.org/10.1108/14676371011058541>
- Schmidt, J. (2009, December 28). As colleges add green majors and minors, classes fill up. *USA Today*. Retrieved from <http://www.usatoday.com>
- Ségalas, J. (2009). *Engineering education for a sustainable future* [Doctoral dissertation]. Càtedra UNESCO de Sostenibilitat, Universitat Politècnica de Catalunya, Spain. <http://hdl.handle.net/10803/5926>
- Ségalas, J., Ferrer-Balas, D., Svanström, M., Lundqvist, U., & Mulder, K. F. (2009). What has to be learnt for sustainability? A comparison of bachelor engineering education competences at three European universities. *Sustainable Science*, 4(1), 17-27. <http://dx.doi.org/10.1007/s11625-009-0068-2>

- Shriberg, M. (2002). Institutional assessment tools for sustainability in higher education. Strengths, weaknesses, and implications for practices and theory. *International Journal of Sustainability in Higher Education*, 3(3), 254-270. <http://dx.doi.org/10.1108/14676370210434714>
- UNESCO. (2009). Education for sustainable development and climate change. *Policy Dialogue*, 4. (UNESCO Doc. No. ED-2009/WS/10). Retrieved from <http://unesco.org>
- UNESCO. (2011). Education for sustainable development. An expert review of process and learning. Commissioned by UNESCO. Paris, France: Daniella Tilbury.
- UNESCO, UN University, International Association of Universities, Third World Academy of Sciences, African Academy of Sciences, Science Council of Asia, International Council for Science, World Federation of Engineering Organizations, Copernicus-Campus, Global Higher Education for Sustainability Partnership, & University Leaders for a Sustainable Future. (2002). *Ubuntu declaration on education and science and technology for sustainable development*. World Summit on Sustainable Development, Johannesburg, South Africa.
- Wade, R. (2008, Spring). Education for sustainable development. *Policy and Practice*, 6, 30-49.
- Van Weenen, H. (2000). Towards a vision of a sustainable university. *International Journal of Sustainability in Higher Education*, 1(1), 20-34. <http://dx.doi.org/10.1108/1467630010307075>
- Velázquez, L., Munguia, N., & Sánchez, M. (2005). Deterring sustainability in higher education institutions: An appraisal of the factors which influence sustainability in higher education institutions. *International Journal of Sustainability in Higher Education*, 6(4), 383-391. <http://dx.doi.org/10.1108/14676370510623865>
- Waas, T., Verbruggen, A., & Wright, T. (2010). University research for sustainable development: Definition and characteristics explored. *Journal of Cleaner Production*, 18(7), 629-636. <http://dx.doi.org/10.1016/j.jclepro.2009.09.017>
- Watson, M. K., Noyes, C., & Rodgers, M. O. (2013). Student perceptions of sustainability education in civil and environmental engineering at the Georgia Institute of Technology. *Journal of Professional Issues in Engineering Education and Practice*, 139(3), 235-243. [http://dx.doi.org/10.1061/\(ASCE\)EI.1943-5541.0000156](http://dx.doi.org/10.1061/(ASCE)EI.1943-5541.0000156)
- Wiek, A., Withycombe, L., & Redman, C. L. (2011). Key competencies in sustainability: A reference framework for academic program development. *Sustainability Science*, 6(2), 203-218. <http://dx.doi.org/10.1007/s11625-011-0132-6>
- Wright, T. S. A., & Wilton, H. (2012, August). Facilities management directors' conceptualizations of sustainability in higher education. *Journal of Cleaner Production*, 31, 118-125. <http://dx.doi.org/10.1016/j.jclepro.2012.02.030>
- Yasin, R. M., & Rahman, S. (2011). Problem oriented project based learning (POPBL) in promoting education for sustainable development. *Procedia - Social and Behavioral Sciences*, 15, 289-293. <http://dx.doi.org/10.1016/j.sbspro.2011.03.088>